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(54) **AUTO CALIBRATION METHOD AND APPARATUS FOR WHEEL BALANCER EQUIPMENT**

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  G01M 1/02 (2006.01)
  G01M 1/16 (2006.01)
(52) **U.S. Cl.**
  CPC .. **G01M 1/16** (2013.01); **G01M 1/02** (2013.01)
(58) **Field of Classification Search**
  CPC G01M 1/225; G01M 1/326; G01M 1/02; G01M 1/30; G01M 1/10
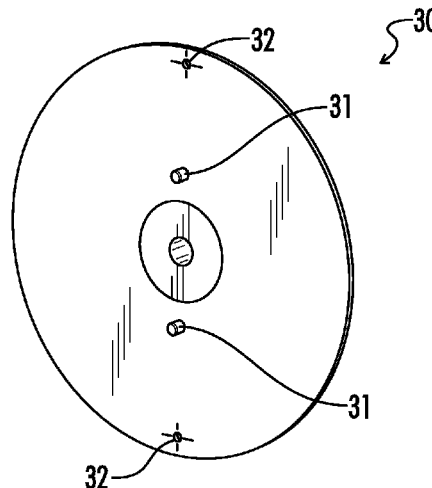 See application file for complete search history.

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(57) **ABSTRACT**

A method of calibrating an electronic wheel balancer includes mounting a calibration wheel on the balancer shaft, the calibration wheel including mounting pins configured to engage mounting holes on a face plate. The balancer emits a visible towards the calibration wheel, the beam indicating a home position for an inner plane calibration weight on the calibration wheel. The calibration wheel is rotated to the home position and an inner weight plane calibration weight is attached to the calibration wheel. The balancer shaft is automatically rotated to obtain sensor data from force transducers on the balancer. Using the sensor data, the balancer automatically calculates and stores inner weight plane reference data. The motor shaft is stopped and the inner plane calibration weight is moved to an outer weight plane position on the calibration wheel. The shaft is again automatically rotated so that the balancer can obtain more sensor data from the force transducers and automatically calculate and store outer weight plane reference data.
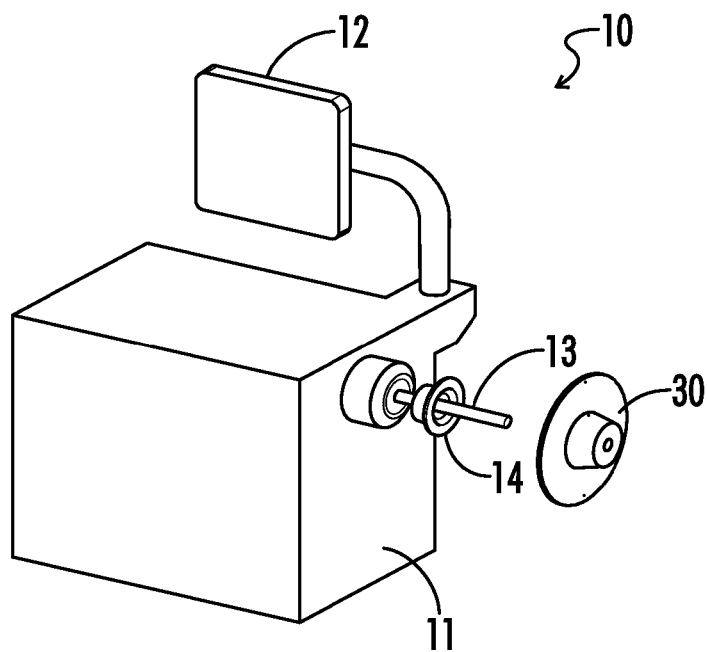
1 Claim, 6 Drawing Sheets
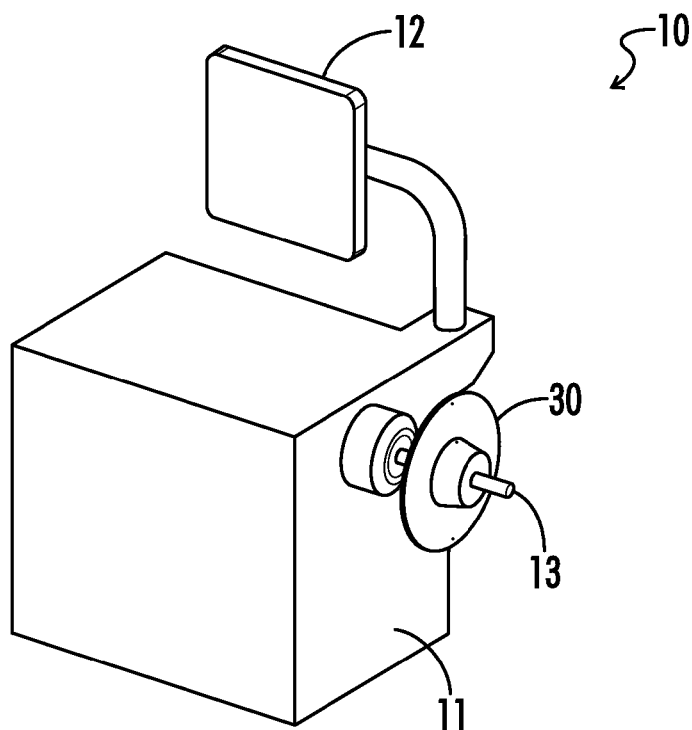
FIG. 1
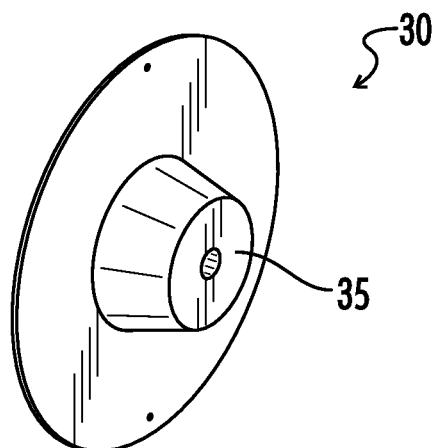*(PRIOR ART)*

FIG. 2
(PRIOR ART)
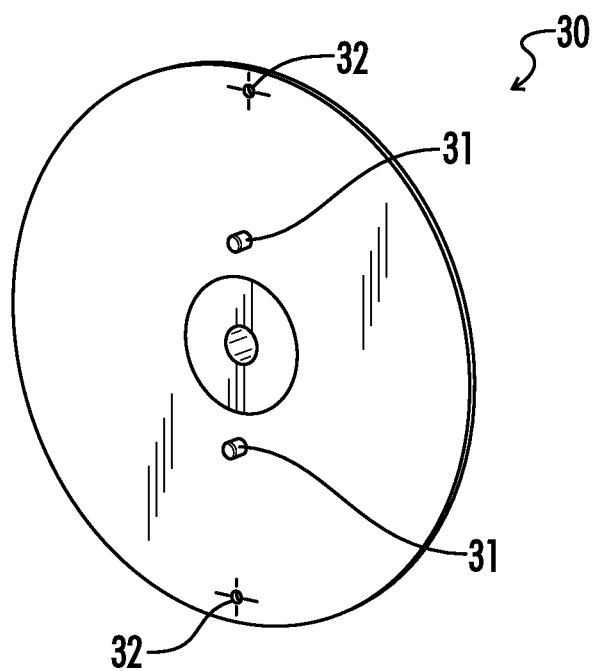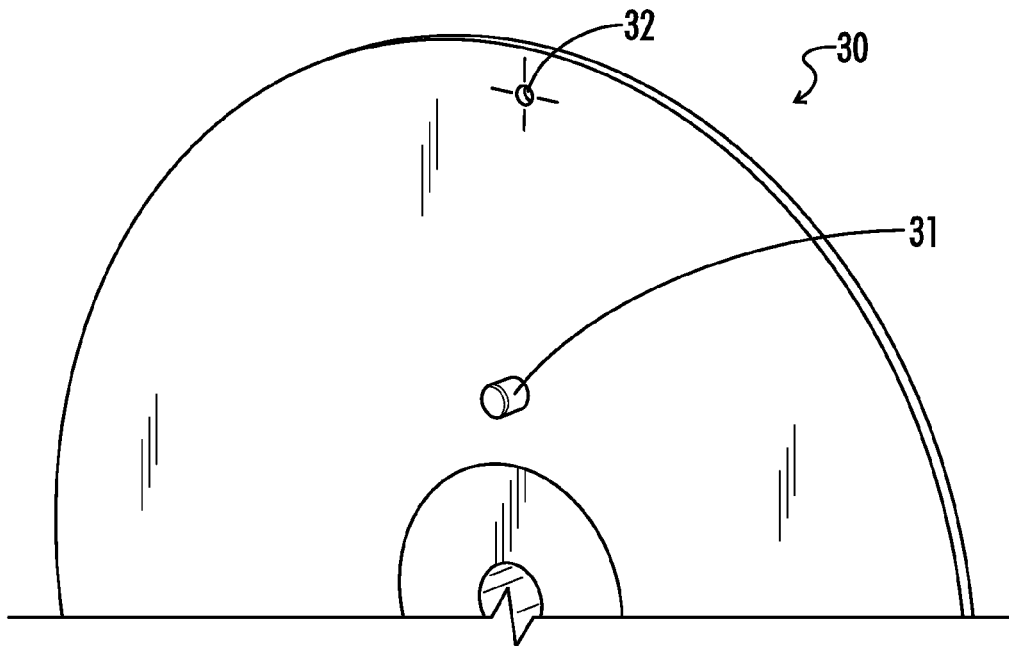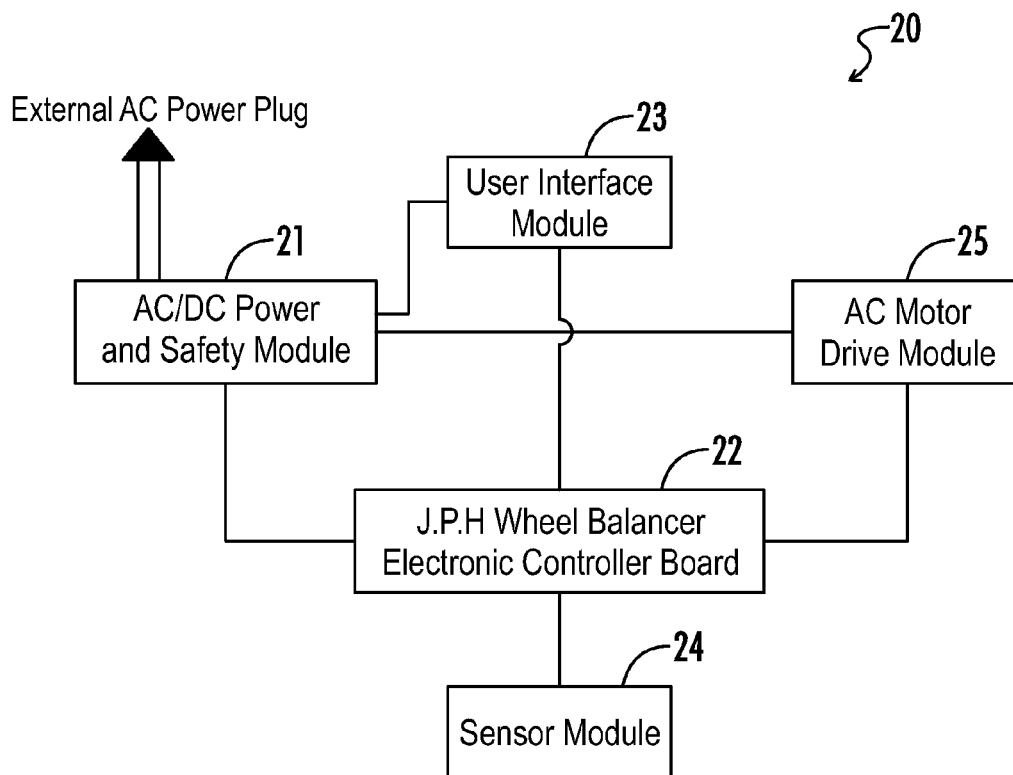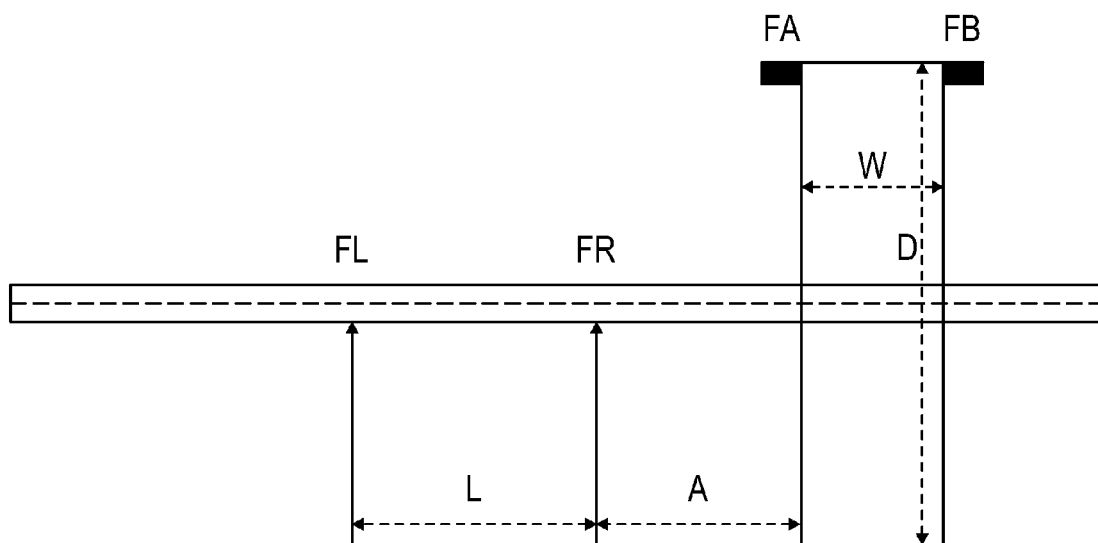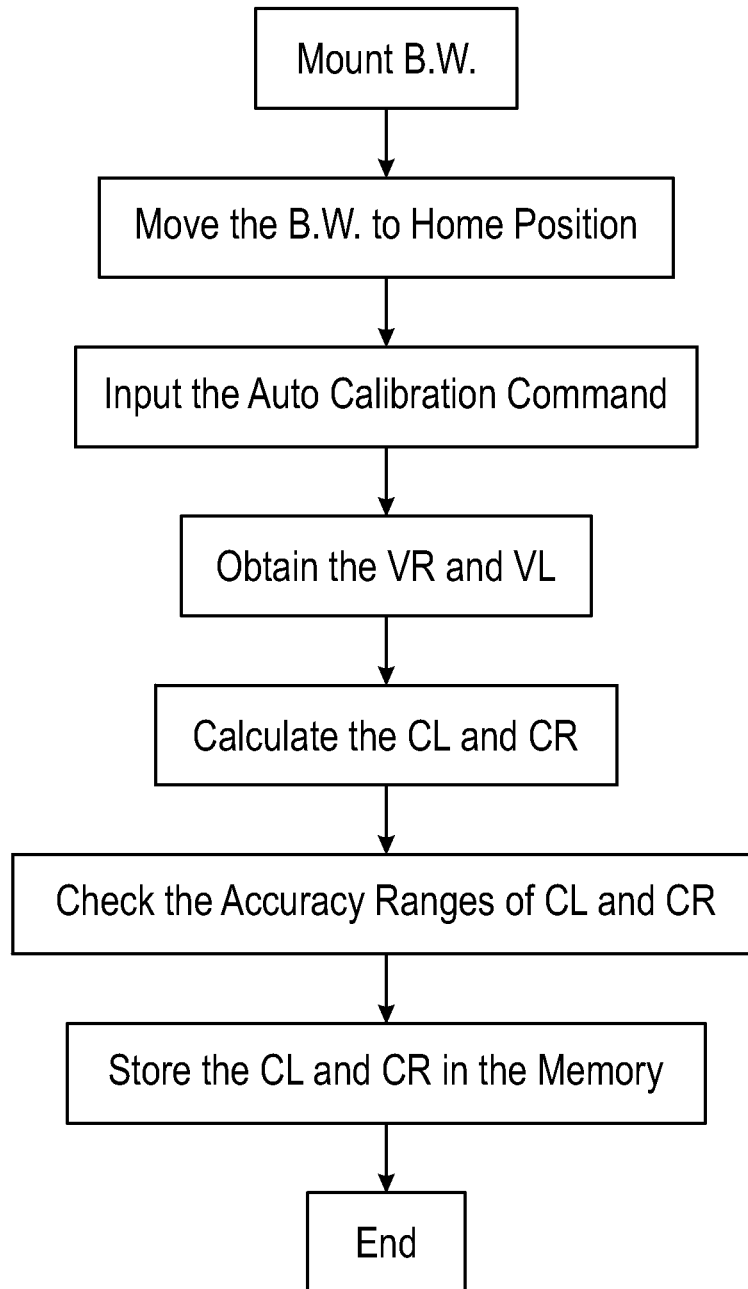
30

35

FIG. 3

30

32

31

31

32

FIG. 4

FIG. 5

External AC Power Plug

23

User Interface
Module

25

20

21

AC/DC Power
and Safety Module

AC Motor
Drive Module

22

J.P.H Wheel Balancer
Electronic Controller Board

24

Sensor Module

FIG. 6
(PRIOR ART)

FA   FB

FL   FR   W

D

L   A

FIG. 7

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          ┌─────────────────────┐
          │      Mount B.W.     │
          └─────────────────────┘
                     │
                     ▼
      ┌───────────────────────────────┐
      │  Move the B.W. to Home Position │
      └───────────────────────────────┘
                     │
                     ▼
      ┌───────────────────────────────┐
      │  Input the Auto Calibration Command │
      └───────────────────────────────┘
                     │
                     ▼
        ┌───────────────────────────┐
        │    Obtain the VR and VL    │
        └───────────────────────────┘
                     │
                     ▼
        ┌───────────────────────────┐
        │    Calculate the CL and CR │
        └───────────────────────────┘
                     │
                     ▼
    ┌───────────────────────────────────┐
    │ Check the Accuracy Ranges of CL and CR │
    └───────────────────────────────────┘
                     │
                     ▼
    ┌───────────────────────────────────┐
    │  Store the CL and CR in the Memory │
    └───────────────────────────────────┘
                     │
                     ▼
          ┌─────────────────────┐
          │         End         │
          └─────────────────────┘
```

FIG. 8

AUTO CALIBRATION METHOD AND APPARATUS FOR WHEEL BALANCER EQUIPMENT

CROSS-REFERENCES TO RELATED APPLICATIONS

This application claims benefit of the following patent application which is hereby incorporated by reference: U.S. Provisional Patent Application No. 61/601,724 entitled "An Auto Calibration Method and its Apparatus for Wheel Balancers," filed Feb. 22, 2012.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO SEQUENCE LISTING OR COMPUTER PROGRAM LISTING APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

The present invention relates generally to methods and devices for balancing vehicle wheel and tire assemblies. More particularly, the present invention pertains to methods and devices for calibrating an electronic wheel balancer apparatus.

Electronic wheel balancers are well known in the art. An example of a conventional wheel balancer 10 is shown in FIGS. 1 and 2. Typically, such a balancer 10 will include a housing or base unit 11 and an operator panel 12 mounted above the base unit. The base unit will contain control electronics, sensors, and an electric motor (not shown). The electric motor shaft 13 will extend laterally outside the base unit 11. A hub and faceplate assembly 14 will be affixed to the shaft to accommodate the mounting of a vehicle tire and wheel assembly for balancing.

A typical arrangement of a control system 20 for an electronic wheel balancer is shown in FIG. 6. An AC/DC power supply and safety module 21 is configured to receive power from the AC grid and then to distribute appropriate supply voltages and currents to the other balancer components. A control board 22 contains processing logic, data interface circuitry, and device interface circuitry to manage operation of the balancer, including performing the necessary balancer calculations. A user interface module 23 is coupled to the control board 22 and to the operator panel 12 so that the operator of the balancer can enter commands and receive prompts and information about operation of the balancer 10. A sensor module 24 is also coupled to the control board 22 to receive data from pressure or force imbalance transducers that is indicative of the balance conditions of a mounted wheel/tire assembly. An AC motor drive module 25 receives commands from control board 22 to provide for starting, stopping and speed control of the balancer motor.

Further details about, and embodiments of, an electronic wheel balancer that can be used as part of the present inven-

tion are shown in U.S. Pat. No. 7,882,738, the entire disclosure of which is incorporated herein.

Conventionally, electronic wheel balancers have used a wheel of certain size to calibrate the wheel balancer so that the balancer control logic can obtain the balance reference parameters before the user can use the wheel balancer to accurately balance a standard tire and wheel assembly.

What is needed is a method and apparatus for simplifying and fully automating the process for accurately calibrating an electronic wheel balancer.

BRIEF SUMMARY OF THE INVENTION

In one aspect, the present invention is a method of calibrating an electronic wheel balancer having a base unit, a motor shaft extending from the base unit, and a face plate attached to the shaft, the face plate including wheel mounting holes therein. In an embodiment, the method includes mounting a calibration wheel on the motor shaft, the calibration wheel comprising mounting pins configured to engage the mounting holes on the face plate; emitting a visible beam from an indicator light towards the calibration wheel, the beam indicating a home position for an inner plane calibration weight on the calibration wheel; rotating the calibration wheel to the home position; attaching an inner weight plane calibration weight to the BW at the home position; in response to an auto-calibration command, automatically rotating the balancer shaft to obtain sensor data from force transducers on the balancer; using the sensor data, automatically calculating and storing inner weight plane reference data; automatically stopping the motor shaft; and moving the inner plane calibration weight to an outer weight plane position on the calibration wheel.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 is an isometric view of an electronic wheel balancer apparatus and a fully balanced calibration wheel, prior to assembly for auto-calibration in accordance with an embodiment of the present invention.

FIG. 2 is an isometric view of the wheel balancer apparatus and calibration wheel shown in FIG. 1, after the wheel is mounted for auto-calibration.

FIG. 3 is an isometric view of the calibration wheel of FIGS. 1 and 2, showing the face of the wheel opposite the wheel balancer apparatus.

FIG. 4 is an isometric view of the wheel balancer side of an embodiment of the calibration wheel, further showing the indicator crosshairs and mounting pins for the balancer hub and the calibration weight position.

FIG. 5 is an enlarged isometric view of a portion of the calibration wheel embodiment of FIG. 4, showing the inner plane weight position indicator as a cross-hair at the top and bottom of the calibration wheel.

FIG. 6 is a block diagram of an embodiment of a control system for an electronic wheel balancer apparatus.

FIG. 7 is schematic view of a portion of the wheel balancer apparatus and calibration wheel of FIGS. 1-5, further showing an embodiment of the mechanical dimensions for the calibration wheel and pressure transducer positions.

FIG. 8 is a flow chart of one embodiment of the auto-calibration method of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In an embodiment, the wheel balancer auto-calibration method and apparatus of the present invention includes a fully

calibrated balanced wheel, or calibration wheel **30**, fabricated of metal and/or rubber material and having a certain diameter and wheel width as shown in FIGS. **1** and **2**. The calibration wheel mechanical parameters and the pressure transducer locations are known. The calibration wheel **30** of the present invention can be attached to the face plate **14** of a balancer easily, using pins **31** that engage corresponding holes on the face plate **14**.

Looking at FIG. **7**, an embodiment of a pre-fabricated and fully balanced calibration wheel **30** is shown, having a width W and a diameter D. The reference FA designates the inner plane calibration weight location. The reference FB designates the external plane calibration weight location. The locations of two pressure transducers are designated by FL and FR respectively, separated by a distance L. The transducer location FR is separated by distance A to the inner weight plane.

To calibrate the balancer **10**, the calibration constants, the calibration constants CL and CR must be determined for both pressure transducers. This can be done by measuring their respective transducer voltages VL and VR, with known parameters, FA, FB, A, L, and W, in accordance with the following equations:

$$CL=\{FA(A/L)+FB[(A+W)/L]\}/VL;$$

$$CR=-\cdot(FA[(L+A)/L]+FB[(L+A+W)/L]]VR;$$

When the calibration constants CL and CR are obtained, the calibration process is completed.

In an embodiment, the calibration wheel of the present invention includes first and second weight position holes that will allow the operator of the balancer **10** to attach or plug-in the calibration weights for auto-calibration. The calibration weight can be related to the wheel mass with certain mass ratio, Mw/Mw. In the disclosure of the present invention, the balanced calibration wheel **30** may also be referred to as a fully balanced wheel BW.

In an embodiment of the present invention, the balancer **10** is configured with a light source which can emit an indicator light beam to indicate the position of a calibration weight to be attached to the inner weight plane of the BW. This position may also be referred to as the Home Position or HP, and is determined to start the automatic calibration process. The indicator beam light source is controlled by the wheel balancer electronic control system **20** as shown in FIG. **6**. FIG. **4** is an isometric view of the wheel balancer side of an embodiment of the calibration wheel **30**, further showing the weight position indicator crosshairs **32** and mounting pins **31** for the balancer hub and the calibration weight positions respectively. FIG. **3** is an isometric view of the calibration wheel **30**, showing the face of the wheel **30** opposite the wheel balancer **10**, including a center mounting hub **35**.

FIG. **5** is an enlarged isometric view of a portion of the calibration wheel **30**, showing the inner plane weight position indicator as a cross-hair **31** at the top and bottom of the calibration wheel.

Referring to FIG. **8**, to implement the auto-calibration method of the present invention, the operator first performs a conventional mechanical arm calibration as is known in the

art as part of the machine setup process. The BW is then mounted on the shaft **13** of the balancer **10**. The operator will turn the BW to the inner plane weight position, or home position, indicated by the light from the balancer **10**. The operator will attach the calibration weight to the BW and input the auto-calibration command into the user-interface module **23**, using the operator panel **12**. When the balancer processor on control board **22** receives this command, the auto-calibration will first obtain the inner weight plane reference data from the BW.

After the inner weight reference data is obtained and temporally stored, the balancer **10** will stop the motor and shaft automatically within a certain time interval so that the operator may remove the inner plane calibration weight and to attach it to the external plane position. The balancer shaft will rotate again and the external weight reference data will be automatically obtained. The automatic calibration process is now complete with valid results displayed by the user-interface module **23** and operator panel **12** of the balancer **10** after the temporary weight reference data is validated. The temporary stored weight reference data for the inner and outer planes will then be recorded in memory on the wheel balancer control board **22**.

Thus, although there have been described particular embodiments of the present invention of a new and useful Auto Calibration Method and Apparatus for Wheel Balancer Equipment, it is not intended that such references be construed as limitations upon the scope of this invention except as set forth in the following claims.

What is claimed is:

1. A method of calibrating an electronic wheel balancer having a base unit, a motor shaft extending from the base unit, and a face plate attached to the shaft, the face plate including wheel mounting holes therein, the method comprising:

mounting a calibration wheel on the motor shaft, the calibration wheel comprising mounting pins configured to engage the mounting holes on the face plate;

emitting a visible beam from an indicator light towards the calibration wheel, the beam indicating a home position for an inner plane calibration weight on the calibration wheel;

rotating the calibration wheel to the home position;

attaching an inner weight plane calibration weight to the BW at the home position;

in response to an auto-calibration command, automatically rotating the balancer shaft to obtain sensor data from force transducers on the balancer;

using the sensor data, automatically calculating and storing inner weight plane reference data;

automatically stopping the motor shaft;

moving the inner plane calibration weight to an outer weight plane position on the calibration wheel;

in response to a continue command, automatically rotating the balancer shaft to obtain sensor data from the force transducers;

using the sensor data, automatically calculating and storing outer weight plane reference data.

* * * * *